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(54) Title: PROCESS AND DEVICE FOR CONTROLLING AND REGULATING THE MOULD FILLING RATE AND CASTING PRESSURE OF A LOW-PRESSURE CHILL CASTING MACHINE

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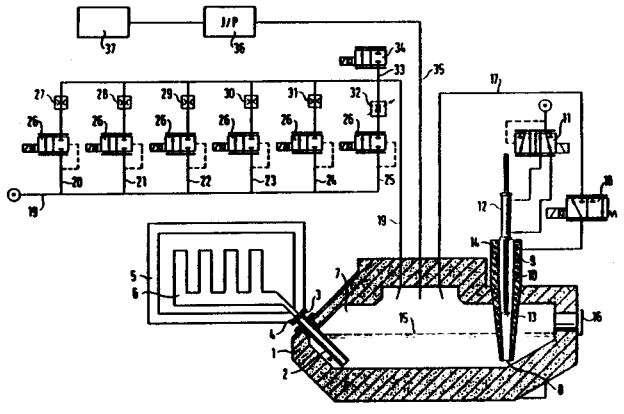

(57) Abstract

The invention relates to a device and a process for controlling and regulating the mould filling rate and casting pressure of a low-pressure chill casting machine, preferably for casting aluminium. The furnace chamber containing the molten casting material can be hermetically sealed and communicates with the mould via a rising pipe connected to the mould. Gas pressure built up in a pressurized gasline forces the casting material from the furnace chamber into the mould. A contact probe (13) can be inserted to varying depths in a probe chamber (10) which extends downward into the furnace chamber (7) and which is open at its lower end (8) to admit the casting material. When contact is made, the contact probe sends a signal to a device (37) for controlling the flow of pressurized gas to the furnace chamber (7). When contact is made, the contact probe can be moved in the probe chamber (10) to a height which is not reached by the molten casting material during the casting process. In addition, a measurement device (36) for measuring the gas pressure in the furnace chamber (7) transmits the measured pressure in the form of a signal to the device (37) for controlling the flow of pressurized gas.

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TRANSLATION

# DEVICE AND METHOD FOR CONTROLLING AND REGULATING THE MOLD FILLING SPEED AND THE CASTING PRESSURE OF A LOW PRESSURE CHILL CASTING MACHINE

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The invention relates to a device and a method for controlling and regulating the mold filling speed and the casting pressure of a low pressure chill casting machine, preferably for aluminium casting, whose hermetically closable furnace chamber or container for receiving the liquid casting material can be connected to the chill mould via a riser pipe leading thereto, via which the casting material is forced into the chill mold by means of gas pressure established in the furnace chamber or container via a gas supply line, at least one contact probe being arranged at an adjustable height in a probe chamber extending into the furnace chamber or container from above and being open at its lower end for the entry of the casting material, which probe supplies a signal to a device for controlling the gas supply flow to the furnace chamber on contact with the casting material rising in the probe chamber as a result of the gas pressure.

Such a control device using at least one contact probe is already known (DE-AS 28 08 588). In this known device, a contact probe, likewise adjustable as to height, is used to control and regulate the gas pressure in the furnace chamber over the entire

casting cycle. The contact probe has there two sensing needles having sensing points located at differing heights. The pressure gas inflow to the furnace chamber or container of the casting material is regulated in such manner that the liquid level of the casting material in the probe chamber integrated in the riser tube is maintained between the lower and the upper sensing points of the contact probe, the probe being adjusted in height according to the desired gas pressure in the furnace chamber or container.

This known device has the disadvantage that during each casting process the sensing points of the contact probe make multiple or even continual contact with the liquid casting material or dip into this, whereby the contact probe rapidly loses its functional precision as a result of adhesion of residues and oxides of the casting material or as a result of attack by the casting material. Moreover, for the probe chamber as a result of the cyclically rising and falling melt therein the danger exists of accretion by melt crystallizing out from the casting material, so that this chamber is heated just as strongly as the riser tube and must be maintained functional by regular cleaning.

Devices are also known for regulating the casting pressure in low pressure chill casting machines (DE-AS 23 31 956) in which the gas pressure in the furnace chamber or in the container for the liquid casting material is adjusted and regulated under computer control according to a predetermined pressure/time curve. The pressure gas is fed in through two gas inlets with differing flow

cross-section. In this connection, several contact probes are provided which are immovably arranged along the path of the riser tube of the casting material and by means of complicated pneumatic regulation members effect partial or complete opening or closure of the two gas inlets and thus ensure a regulatable gas pressure over wide limits according to the pre-set control. These contact probes are reinserted in each casting cycle into the liquid high pressure casting material extending up to or beyond them, so that they are associated with the same disadvantage as the probe in the first mentioned known device.

The invention is therefore based on the object, with a device and method of the type initially mentioned, of maintaining unchanged the functionality of the contact probe over a large number of casting cycles and thus excluding malfunctions in the control of the casting pressure, and arranging the control of the pressure gas feed introduced through the probe in a manner which is constructively as simple and operationally reliable as possible. This is achieved according to the invention in that upon contact with the casting material rising in the probe chamber as a result of the gas pressure, upon which it gives a signal to a device for controlling the gas pressure flow to the furnace chamber or container, the contact probe is movable in the probe chamber receiving it to a position of height such that it is not reached during the casting process by the level of the casting material, and in that a measuring arrangement is provided for measuring the gas pressure prevailing in the upper region of the furnace chamber or container for the casting material which provides the measured gas pressure in the form of a signal to the arrangement for controlling the gas pressure flow.

The contact probe thus comes into operation only once during a casting cycle signalling the onset of contact to the arrangement for control of the gas pressure flow, whereby the sequence of further control and regulation of the gas pressure in the furnace chamber or container can be initiated as a function of time according to a predetermined programme. In this connection, the gas pressure measured at this instant by the measuring arrangement in the furnace chamber or container can be used as a reference pressure for the further control sequence. For further control of the gas pressure in the furnace chamber, the gas pressure given in the furnace chamber or container with the provided measuring arrangement can be continually re-measured and according to the respectively measured actual pressure and the desired pressure pre-set by the control device the gas pressure flow to the furnace chamber or container can be controlled.

The short contact only once during an entire casting cycle between the contact probe and the high pressure casting material in the probe chamber given in the device according to the invention and this method ensures that the contact probe is largely protected and is maintained free of encrustation with casting material.

The contact probe can be adjustable to such a height in the probe chamber that its sensing points lie approximately on the level of the outlet opening of the riser tube which can be connected to the chill mould. This height corresponds approximately to the level of casting material shortly before the beginning of mold filling, thus to a level which is located slightly beneath the mould cavity.

Expediently, the probe chamber, with the exception of its lower opening for the entry of the casting material, is hermetically closable so that above the casting material rising in this chamber a gas pressure can be generated which reliably prevents rising of the casting material to the contact probe at its raised position. For this purpose, the probe chamber can be in connection in its upper region with the furnace chamber or container for the liquid casting material via a pressure gas equalization line prodivided with a closure valve. This closure member can be a changeover valve which is controllable in such manner that at the beginning of a casting cycle it is first open to the upper probe chamber for external air (ventilating position) and closes the ventilation opening upon the onset of contact of the contact probe with the high pressure casting material in the probe chamber and opens the pressure equalization line to the furnace chamber and thus performs gas pressure equalization between the probe chamber and the furnace chamber.

For control of the gas pressure in the furnace chamber, the aperture cross-section of the pressure gas line is expediently adjustable in dependence on the gas pressure preset in the furnace chamber or container by the control programme. In order to ensure setting of the aperture cross-section and thus the amount of gas pressure fed into the furnace chamber with the simplest possible control member, in a preferred embodiment the gas pressure feed line is divided into several branch lines which are brought together again before discharging into the furnace chamber or container and each having an unchangeable aperture cross-section, preferably in the form of a calibrated aperture, for the gas pressure as well as

a closure valve. The calibrated apertures can have differing aperture openings and be individually opened or closed in arbitrary combination by the arrangement for controlling the gas pressure inflow, whereby the respectively required pressure gas inflow to the furnace or container which is responsible for the increasing speed of the casting material in the riser tube can be precisely controlled. This simple closing and opening control is cheap, technically unproblematical and very unlikely to fail.

In Fig. 1 of the drawings is represented a particularly advantageous exemplary embodiment of the control device according to the invention in a low pressure casting apparatus for aluminium casting which will be described in more detail in the following.

Fig. 2 shows the possible gas pressure control with the device according to the invention in the course of a casting cycle in a pressure time diagram.

The casting apparatus illustrated in Fig. 1 consists of a metal smelting furnace 1 into which a riser tube 2 obliquely extends to the vicinity of its base, which tube is provided on its outer end with a connection flange 3 for coupling to a connection flange 4 having an inlet opening of a chill mold 5 with molding cavity 6. Into the furnace chamber 7, a tubular body 9 open at its lower end 8 likewise extends from above to the region of the base, which body 9 delimits a probe chamber 10 in which an electrical contact probe is arranged to be adjustable in height by means of a drive cylinder 12 controlled pneumatically or hydraulically via a valve 11. This contact probe consists of a contact plate 13 which is supported on a guide rod 14 activated by the drive

cylinder 12. The level of the casting material, the metal melt, located in the metal smelting furnace 1 is indicated with 15, which material can be filled into the furnace chamber 7 through a closable inlet 16. By means of the drive cylinder 12, the probe 13 can be adjusted and changed in height in the probe chamber 10 with the guide rod 14.

The probe chamber 10 receiving the probe 13 is hermetically sealed with the exception of its lower entry opening 8 for the casting material, the inlet of a gas pressure equalization line 17 leading to the furnace chamber 7 and a ventilation opening in the changeover valve 18. In the vicinity of the pressure equalization line 17, a pressure gas line 19 discharges into the furnace chamber. This pressure gas line is sub-divided into six branch lines 20 to 25 which are combined together before discharge into the furnace chamber 7 and each of which has an open-shut control valve 26. The branch lines 20 to 24 are furthermore provided with calibrated apertures 27 to 31 determining the flow of the gas volume, which have differing aperture cross-sections. The lines 20 to 25 provided with the calibrated apertures can be opened by their control valves 26 individually or in arbitrary combination, so that thereby the respectively necessary volume of pressure gas for the necessary speed increase in the riser tube 2 can be introduced through the gas feed line 19 into the furnace chamber 7. The control valve 26 in the branch line 25 serves in conjunction with the choke valve 32 also arranged in this branch line moreover for regulation of the leakage equalization.

In order that the pressure gas feed line 19 can also be used for ventilating the furnace chamber 7, a ventilation line 33 is connected to this line with a ventilation valve 34. Furthermore a gas pressure measuring line 35 opens into the furnace chamber 7 and leads to a measuring device 36 constructed as a pressure-flow converter which supplies the gas pressure in the furnace chamber 7 registered thereby via the line 35 in the form of electrical signals to an electrical control device 37 which is arranged for controlling the valves 11,18,26 and 34.

The mode of operation of the control device of this exemplary embodiment of the invention operates as follows:

First the probe 13 is adjusted to a height within the probe chamber 10 which approximately corresponds to the outlet opening of the riser tube 2 in the region of its coupling flange 3. The changeover valve 18 is so switched that the upper probe chamber is ventilated. Then with closed ventilation valve 34 with appropriate setting of the control valves 26 in the branch lines 20 to 25 of the pressure gas feed lines 19 pressure gas is introduced into the furnace chamber 7 until the metal melt in the probe chamber 10 has been pressed up to the lower edge of the contact probe 13 by the gas pressure established thereby above the metal melt in the furnace chamber. The onset of contact between the highly pressurized metal melt and the contact probe 13 is registered thereby and reported to the electrical control device 37 which then causes further control of the pressure gas flow 19 into the furnace chamber according to a

predetermined programme. Simultaneously, the probe 13 is raised by the drive cylinder 12 to a height within the probe chamber 10 at which it remains out of contact with the high pressure casting material in the probe chamber throughout the entire following casting process and the changeover valve 18 is switched so that the ventilation opening of upper probe chamber is closed and the pressure equalization line 17 is opened, whereby the gas pressure in the furnace chamber 7 is diverted to the probe chamber 10 above the metal melt located there and the rising metal melt in this chamber is pressed back to the level of the melt located in the furnace chamber 7.

Moreover, the gas pressure obtaining in the furnace chamber 7 at this time is measured by the measuring device and its measuring result is electrically supplied to the electrical control device 37 which uses the instantaneously given level of gas pressure in the furnace chamber 7 as reference quantity for further control of the casting pressure in the furnace chamber.

From this time, the further temporal control and regulation of the casting pressure and thus the rising speed and rising level of the metal melt to be introduced through the riser tube 2 into the hollow mold chamber 6 of the chill mold 5 is performed by control over time of the volume flow of the pressure gas to be introduced into the furnace chamber 7 via the pressure gas line 19 according to a pre-programmed pressure-time curve 38, as may be seen from Fig. 2.

The numbers located in rectangles in Fig. 2 designate measuring points at which in the course of a casting cycle the pressure gas inflow and thus the further time variation of the pressure increase in the furnace chamber experiences change. The first curve section located between measuring points 1 and 2 shows the increase of the gas pressure up to the time at which the metal melt has reached the contact probe 13 in the probe chamber 10 set at the height of the coupling flange 3 of the riser tube 2 (level line A). During this phase of pressure increase in the furnace, all control valves 20 to 25 are open in the gas pressure feed line 19. This pressure build-up phase is followed by the phase of beginning filling of the hollow mold chamber 6 in the chill mold 5 which is characterized by the curve section between the measuring points 2 and 3 of the pressure-time curve according to Fig. 2. The pressure increase per unit time is somewhat smaller than in the preceding pressure build-up phase as appears from Fig. 2.

This is followed by the main mold filling phase which is characterized by the curve section between the measuring points 3 and 4 in Fig. 2, whereafter the phase of the end of mold filling with further pressure increase according to the curve section between measuring points 4 and 5 takes place until the hollow mold chamber 6 is completely filled (level line B). This phase is followed with further strong pressure increase by the re-pressurizing phase which is characterized by the curve section between the measuring points 5 and 6, and then the phase of maintaining the increased pressure serving for topping up the mold which is characterized by the curve section between the measuring points 6 and 7.

At the end of the re-pressurizing phase, by opening of the ventilation valve 34, the gas pressure in the furnace chamber 7 is reduced to zero, which is represented in Fig. 2 by the curve section between the measuring points 7 and 8. In this connection, the still liquid metal falls from the casting passage and riser tube into the furnace.

According to the size of the desired pressure build-up in the curve sections between the measuring points 1 to 6, the control valves 26 are opened or closed in various combinations such as results from the following example:

Table

| Curve Sections | Control valves 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|---|
| 1-2 | + | + | + | + | + | + | Pressure increase (Metal rises to the contact probe) |
| 2-3 | - | + | - | - | + | + | Beginning of mold filling |
| 3-4 | + | - | - | - | + | - | Mold filling |
| 4-5 | + | + | - | - | + | + | End of mold filling |
| 5-6 | + | + | + | + | + | + | Increase of re-pressurization |
| 6-7 | - | - | - | - | - | - | Maintenance of the re-pressurization |
| 7-8 | - | - | - | - | - | - | Ventilation (pressure reduction to atmospheric pressure) |

\+ = control valve open
\- = control valve closed

The control valves remain in the individual phases of the casting cycle in their set position until the gas pressure measured continuously by the measuring device 36 in the furnace chamber 7 has reached the respective pre-set desired pressure according to the control programme.

The regulation and leak loss valve 26 located in the branch 25 serves for maintaining the re-pressurization for the duration of the above-mentioned topping-up phase, which valve continuously permits a determined amount of pressure gas to flow into the furnace interior chamber 7 according to leakages in the entire gas pressure system determined according to the gas pressure measurement. Monitoring of the constancy of the gas pressure during the re-pressurization phase can serve to register changes in the overall leakage losses and to effect compensation by appropriate further regulation of the loss equalization.

CLAIMS

1. Device for controlling and regulating the mold filling speed and casting pressure of a low pressure chill casting machine, whose hermetically closable furnace chamber receiving the casting material is connected to the chill mold via a riser tube leading to this, via which the casting material is pressed into the chill mold by means of gas pressure established in the furnace chamber via a pressure gas feed line, at least one contact probe being arranged at an adjustable height in a probe chamber extending into the furnace chamber from above and being open at its lower end for the entry of the casting material, which probe provides a signal to an arrangement for controlling the pressure gas inflow on the onset of contact with the casting material rising in the probe chamber as a result of the gas pressure, characterized in that on onset of contact the contact probe (13) is adjustable in the probe chamber (10) to a height position which is not reached during the casting process by the level of liquid casting material, and in that a measuring arrangement (36) is provided for measuring the gas pressure in the furnace chamber (7) which arrangement provides the measured pressure in the form of a signal to an arrangement (37) for controlling the pressure gas inflow.

2. Device according to claim 1 characterized in that the contact probe (13) is movable in and out by a pneumatically or hydraulically controlled drive cylinder (12).

3. Device according to claim 1 characterized in that the contact probe (13) is adjustable in the probe chamber (10) to a height position such that its sensing points lie approximately at the height of the outlet opening of the riser tube (2) connectable to the chill mold (5).

4. Device according to claim 1 characterized in that the probe chamber has a closable ventilation opening in its upper region.

5. Device according to claim 1 or 4 characterized in that the probe chamber (10) can be hermetically sealed with the exception of its lower opening end (8) for the entry of the casting material.

6. Device according to claim 4 characterized in that the probe chamber (10) is connected at its lower region to the furnace chamber (7) via a pressure gas equalization line (17) closable by a changeover valve (18).

7. Device according to claim 4 and 6 characterized in that the changeover valve (18) is controllable in such manner that upon onset of contact of the contact probe (13) with the high pressure casting material in the probe chamber (10) it switches such that the ventilation opening of the probe chamber is closed and the pressure equalization line (17) is open.

8. Device according to claim 1 characterized in that the aperture cross-section of the pressure gas feed line (19) can be changed in dependence upon the desired gas pressure in the furnace chamber.

9. Device according to claim 8 characterized in that for setting the desired gas pressure in the furnace chamber (7) the gas pressure feed line (19) is sub-divided into a plurality of branch lines (20 to 25) which are brought together again before discharge into the furnace chamber and which have respective fixed aperture cross-section (calibrated apertures 27 to 31) for the pressure gas and a control valve (26) constructed as an open-shut valve.

10. Device according to claim 9 characterized in that the control valves are controllable by an arrangement (37) for controlling the pressure gas feed flow.

11. Device according to claim 1 characterized in that in the pressure gas feed line (19) discharging into the furnace chamber (7) a leak valve (26,32) is arranged which is controllable in dependence upon the gas pressure losses caused by leakage as measured in the furnace chamber.

12. Method for controlling the casting pressure of a low pressure chill casting apparatus (metal casting apparatus) comprising a device according to one or more of claims 1 to 11 characterized in that on the onset of contact of the contact probe with the high pressure casting material in the probe chamber the gas pressure in the furnace chamber is measured and via an electrical signal is used as reference pressure for further control of the pressure gas feed flow to the furnace chamber.

13. Method according to claim 12 characterized in that after onset of contact of the contact probe with the high pressure casting material in the probe chamber the gas pressure in the furnace chamber is continually measured and the gas pressure feed flow to the furnace chamber is controlled according to the respective desired pressure in the furnace chamber pre-set by the control programme.

## ABSTRACT

Device and method for controlling and regulating the mold filling speed and the casting pressure of a low pressure chill casting machine.

A device and method for controlling and regulating the mold filling speed and the casting pressure of a low pressure chill casting machine, preferably for aluminium casting, whose hermetically closable furnace chamber receiving the liquid casting material can be connected to the chill mold via a riser tube leading to this, via which the casting material is pressed into the chill mold by means of gas pressure established in the furnace via a pressure gas feed line. A contact probe (13) is arranged at an adjustable height in a probe chamber (10) extending from above into the furnace chamber (7) and open at its lower end (8) for the entry of the casting material, which probe on the occurrence of contact supplies a signal to an arrangement (37) for control of the gas pressure feed flow to the furnace chamber (7). This contact probe is movable on the onset of contact in the probe chamber (10) to such a height that during the casting process is not reached by the level of the liquid casting material. Furthermore, a measuring arrangement (36) is provided for measuring the gas pressure in the furnace chamber (7), which supplies the measured pressure in the form of a signal to the arrangement (37) for controlling the pressure gas feed flow.

(Figure 1.)

Fig. 1

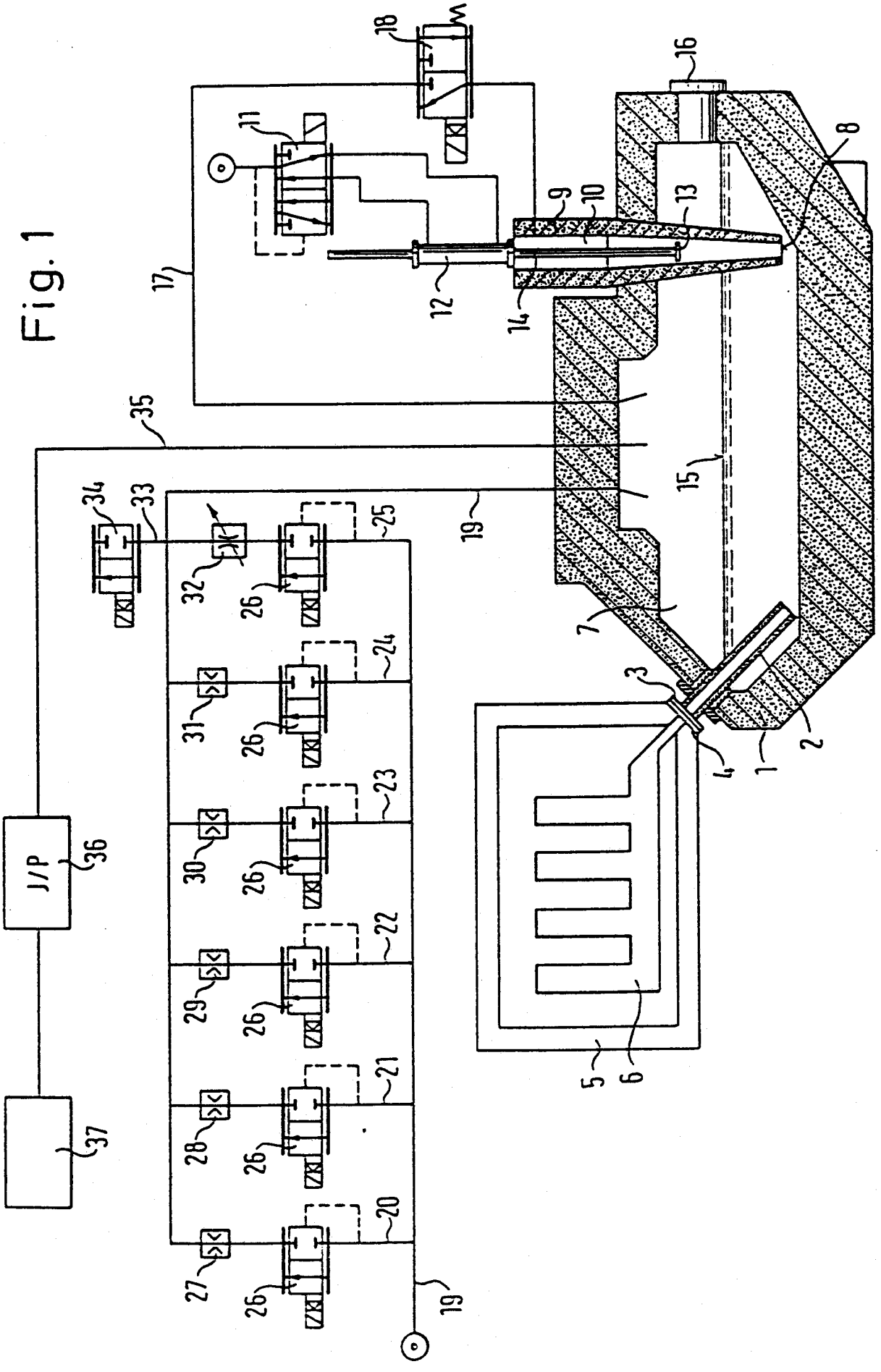
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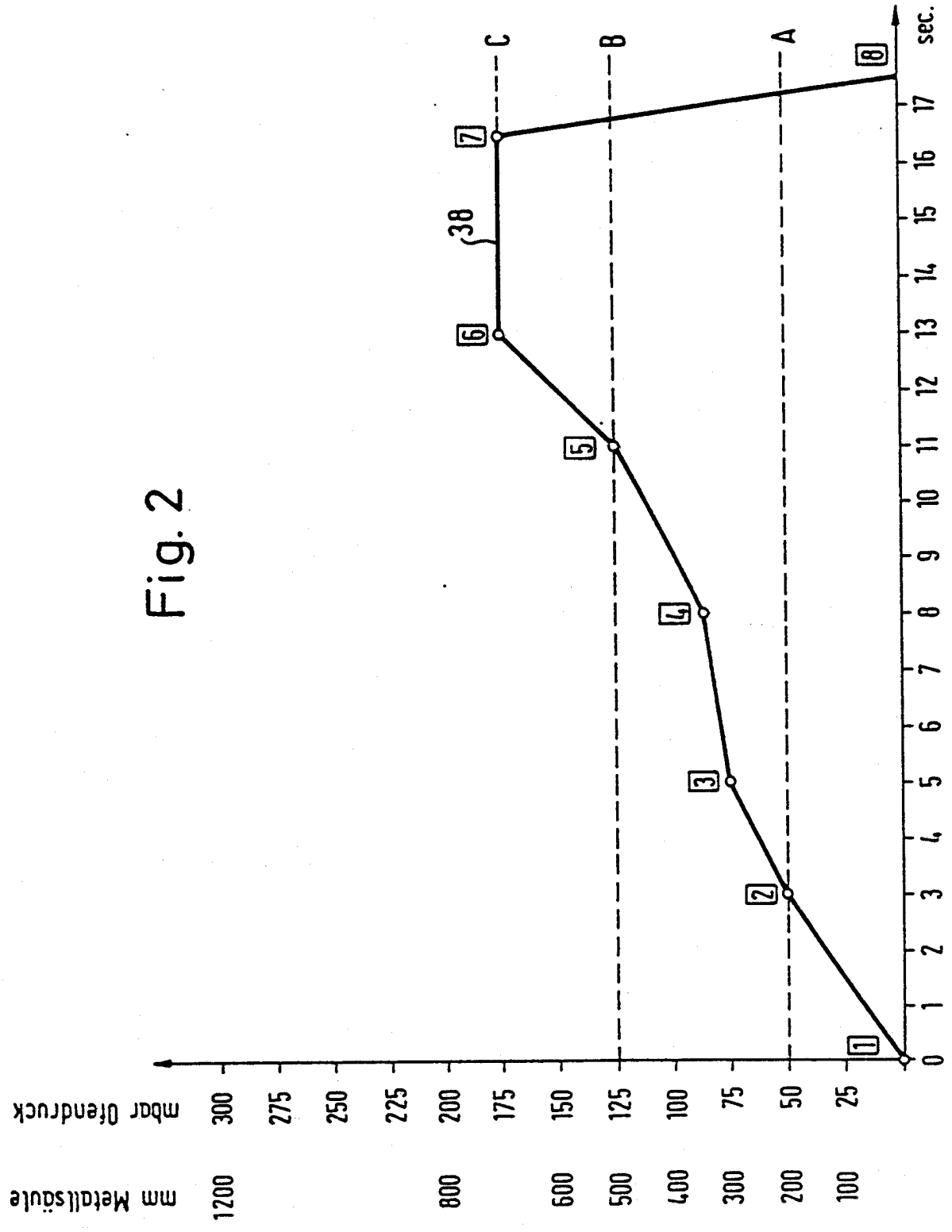
Fig. 2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